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Influence of dietary protein level, amino acid supplementation, and dietary energy levels on growing-finishing pig performance and carcass composition[1]

B. J. Kerr[2]*, L. L. Southern†, T. D. Bidner†, K. G. Friesen‡, and R. A. Easter§

*USDA-ARS Swine Odor and Manure Management Research Unit, Ames, IA 50011-3310; †Department of Animal Sciences, Louisiana State University Agricultural Center, Baton Rouge 70803; ‡University of Arkansas, Department of Animal Sciences, Fayetteville 72701; and §Department of Animal Sciences, University of Illinois, Urbana 61801

ABSTRACT: Two experiments were conducted to determine the effects of feeding reduced-CP, AA-supplemented diets at two ambient temperatures (Exp. 1) or three levels of dietary NE (Exp. 2) on pig performance and carcass composition. In Exp. 1, 240 mixed-sex pigs were used to test whether projected differences in heat increment associated with diet composition affect pig performance. There were 10 replications of each treatment with four pigs per pen. For the 28-d trial, average initial and final BW were 28.7 kg and 47.5 kg, respectively. Pigs were maintained in a thermoneutral (23°C) or heat-stressed (33°C) environment and fed a 16% CP diet, a 12% CP diet, or a 12% CP diet supplemented with crystalline Lys, Trp, and Thr (on an as-fed basis). Pigs gained at similar rates when fed the 16% CP diet or the 12% CP diet supplemented with Lys, Trp, and Thr ($P > 0.10$). Pigs fed the 12% CP, AA-supplemented diet had a gain:feed similar to pigs fed the 16% CP diet when housed in the 23°C environment but had a lower gain:feed in the 33°C environment (diet × temperature, $P < 0.01$). In Exp. 2, 702 gilts were allotted to six treatments with nine replicates per treatment. Average initial and final BW were 25.3 and 109.7 kg, respectively. Gilts were fed two levels of CP (high CP with minimal crystalline AA supplementation or low CP with supplementation of Lys, Trp, Thr, and Met) and three levels of NE (high, medium, or low) in a 2 × 3 factorial arrangement. A four-phase feeding program was used, with diets containing apparent digestible Lys levels of 0.96, 0.75, 0.60, and 0.48% switched at a pig BW of 41.0, 58.8, and 82.3 kg, respectively. Pigs fed the low-CP, AA-supplemented diets had rates of growth and feed intake similar to pigs fed the high-CP diets. Dietary NE interacted with CP level for gain:feed ($P < 0.06$). A decrease in dietary NE from the highest NE level decreased gain:feed in pigs fed the high-CP diet; however, gain:feed declined in pigs fed the low-CP, AA-supplemented diet only when dietary NE was decreased to the lowest level. There was a slight reduction in longissimus area in pigs fed the low-CP diets ($P < 0.08$), but other estimates of carcass muscle did not differ ($P > 0.10$). These data suggest that pigs fed low-CP, AA-supplemented diets have performance and carcass characteristics similar to pigs fed higher levels of CP and that alterations in dietary NE do not have a discernible effect on pig performance or carcass composition.

Key Words: Amino Acids, Growing-Finishing Pigs, Net Energy, Temperature

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Introduction

The use of low-CP, AA-supplemented diets may reduce feed costs and N excretion. However, pigs fed low-CP, AA-supplemented diets have been shown to have fatter carcasses compared with pigs fed high-CP diets (Kerr et al., 1995; Tuitoek et al., 1997b). The increased fatness in pigs fed low-CP, AA-supplemented diets may be partially due to more dietary energy being available for fat synthesis as a result of reduced energy expenditure for catabolization of ex-

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[2]Correspondence: USDA-ARS-MWA-SOMMRU, National Swine Research and Information Center, NSRIC-2167 (phone: 515-294-0224; fax: 515-294-1209; E-mail: kerr@nsric.ars.usda.gov).

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cess dietary protein. Excess CP intake has been shown to increase energy expenditure (Buttery and Boorman, 1976) and impact organ size and energy metabolism (Yen, 1997; Nyachoti et al., 2000). Noblet et al. (1987) observed that pigs fed diets containing 37.5 g protein/Mcal DE had lower heat production (**HP**) compared with pigs fed a diet containing 45 g protein/Mcal DE. Kerr et al. (2003) reported that pigs fed a 12% CP, AA-supplemented diet had a lower HP than pigs fed a 16% CP diet. In addition, reduced plasma urea N observed in pigs fed the low-CP, AA-supplemented diet (Lopez et al., 1994; Kerr and Easter, 1995) is another indication of a reduced energy need for deaminating excess AA.

Heat increment (**HI**) is the amount of heat released because of the energy costs of the digestive and metabolic processes. Heat production includes the energy associated with HI, energy required for maintenance, and energy expended in response to changes in the environment (NRC, 1998). To reduce HI, heat-stressed pigs voluntarily decrease feed intake, causing a decrease in growth with little change in feed conversion (Nienaber et al., 1987). In heat stress conditions, an improved growth performance by feeding diets formulated to minimize AA excesses has been observed in chicks (Waldroup et al., 1976) and pigs (Stahly et al., 1991).

The objective of the present studies was to determine whether projected differences in the HI of diets or the NE level of the diet would affect pig growth performance and carcass traits.

Table 1. Composition of Experiment 1 diets (%, as-fed basis)

	Dietary treatments		
Ingredient, %	16% CP	12% CP + AA	12% CP
Corn	75.54	84.73	85.32
Soybean meal, 47.8%	21.91	12.00	12.00
Dicalcium phosphate	1.06	1.26	1.26
Limestone	0.94	0.87	0.87
Trace mineral salt[a]	0.35	0.35	0.35
Vitamin mix[b]	0.10	0.10	0.10
Tylosin[c]	0.10	0.10	0.10
L-Lysine·HCl	—	0.37	—
L-Tryptophan	—	0.06	—
L-Threonine	—	0.16	—
Calculated composition, %[d]			
Crude protein	16.00	12.00	12.00
Analyzed	16.77	13.02	12.90
Lys	0.84	0.84	0.55
Analyzed	0.97	0.84	0.56
Trp	0.17	0.17	0.11
Analyzed	0.15	0.15	0.09
Thr	0.65	0.65	0.49
Analyzed	0.70	0.63	0.46
TSAA	0.58	0.47	0.47
Calcium	0.65	0.65	0.65
Phosphorus, total	0.55	0.55	0.55
ME, Mcal/kg	3.28	3.30	3.30

[a]Trace mineral mix provided per kilogram of diet: Se, 0.1 mg (Na_2SeO_3); I, 0.35 mg (CaI_2); Cu, 8 mg ($CuSO_4 \cdot 5H_2O$); Mn, 20 mg (MnO); Fe, 90 mg ($FeSO_4 \cdot H_2O$); Zn, 100 mg (ZnO); NaCl, 2.87 g.

[b]Vitamin mix provided per kilogram of diet: vitamin A, 3,300 IU; vitamin D_3, 330 IU; vitamin E, 22 IU; menadione sodium bisulfate, 2.2 mg; riboflavin, 2.2 mg; D-Ca pantothenate, 6.1 mg; niacin, 16.6 mg; choline chloride, 165.4 mg; vitamin B_{12}, 0.02 mg.

[c]Provided 11 mg tylosin/kg of diet.

[d]Calculated values for Lys, Thr, Trp, and sulfur AA (TSAA) were based on analysis of ingredients for CP and CP:AA ratios for estimates of amino acid concentration. Crude protein analyses were 7.4% for the corn and 47.8% for the soybean meal.

Experimental Procedures

All experimental procedures were approved by the University of Illinois Committee on Laboratory Animal Care.

Experiment 1. Two hundred forty, Landrace × Hampshire crossbred pigs were used to test the hypothesis that pigs will perform differently under heat stress (33.8 vs. 24.5°C) when fed diets varying in CP and crystalline AA supplementation (16% CP, 12% CP, or 12% CP + AA). Pigs were weaned at approximately 4 wk of age and fed a common diet until allotted to treatment. Pigs were housed in 1.4- × 2.3-m pens with floors that were half solid concrete and half concrete slats. The thermoneutral temperature room was equipped with two 8.8-kW natural gas heaters, whereas the heat-stress room had additional heat provided by a 17.6-kW and a 29.3-kW natural gas heater. Temperature and relative humidity were recorded continuously by a calibrated hygrothermograph located in the center of each building, 25 cm above the floor. Temperature and relative humidity for the thermoneutral and heat-stress rooms averaged 24.5°C (SD 1.71), 57.0% relative humidity (SD 6.78), and 33.8°C (SD 1.45), 37.1% relative humidity (SD 6.13), respectively. Temperature and relative humidity remained constant throughout the day. Photoperiod was regulated to provide 10 h of normal-intensity light followed by 14 h of low-intensity light. Pigs were adapted to the environmental temperature for 1 wk before initiation of dietary treatments because changes in environmental temperature can cause alterations in body water, thereby distorting short-term performance results (Morrison and Mount, 1971; Phillips et al., 1982).

Diets (Table 1) were formulated using analyzed CP, Lys, and Thr composition values for the corn and soybean meal. Nitrogen analysis of ingredients and diets were done by the macro-Kjeldahl procedure (AOAC, 1984). Lysine and Thr concentrations of the ingredients and diets were determined using ion-exchange chromatography (Beckman 119 CL Amino Acid Analyzer, Palo Alto, CA) after hydrolysis of the samples in 6 *N* HCl for 22 h at 100°C under a nitrogen atmosphere. Tryptophan addition to the low-CP diet was based on the expected Trp level in the corn and soybean meal calculated from tabular values of CP-to-AA ratios (NRC, 1988) and the analyzed CP level of each ingredient. Tryptophan analysis on the diets was done by ion-exchange chromatography following alkaline hydrolysis of the samples as described previously (Sato et al., 1984). Lysine, Trp, and Thr additions to the 12% CP diet were made to equal the total levels calculated to be present in the 16% CP diet. Methionine plus Cys levels were not equalized but were formulated similarly to diets used previously (Kerr and Easter, 1995; Kerr et al., 1995) to help explain differences in pig performance, carcass composition, and heat production reported in those experiments. Diets and water were provided for ad libitum consumption using a single automatic nipple drinker and a two-hole self-feeder. Dietary treatments were imposed at an average initial BW of 28.7 kg and continued for 28 d. Individual pig weights and feed disappearance were recorded biweekly to calculate ADG, ADFI, and gain:feed ratio. Following weighing on d 28, a blood sample from the jugular vein of all pigs was obtained, centrifuged for serum separation, and analyzed in triplicate for urea plus ammonia N (**SUN**; Kit No. 640, Sigma Diagnostics, St. Louis, MO).

Each factorial set of treatments was replicated with 10 pens of four pigs each, two gilts and two barrows per pen, in a randomized complete block design. Blocks were formed on the basis of gender, ancestry, and weight. Assignment to treatment was done randomly from within blocks (two temperatures × three diets). Data for each response variable were analyzed by ANOVA using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) with replicate, diet, temperature, and diet × temperature included in the model. The pen of pigs was the experimental unit for all data. The PDIFF option of SAS was used to determine differences between treatment means.

Experiment 2. Seven hundred two gilts (Hampshire × Duroc boar on Yorkshire × Landrace dams) were allotted to treatments on the basis of initial BW, 25.3 kg, to test the hypothesis that modification of dietary NE and CP would impact pig growth performance and carcass composition. Gilts were housed in a commercial, double curtain-sided facility from February to June, 1998. Pens measured 3.91 × 2.44 m, with solid concrete flooring in 40% of the pen and concrete slats in the remaining 60% of the pen. Feed and water were provided for ad libitum consumption throughout the experiment. Pen pig weights and feed disappearance were recorded at the beginning and end of the growth phase to calculate ADG, ADFI, and gain:feed ratio. Each treatment had nine replicates with 13 gilts per pen in a randomized complete block.

Gilts were fed either high-CP or reduced-CP diets and three levels of NE (high, medium, or low), resulting in a 2 × 3 factorial arrangement of treatments. The high-CP diets only had small quantities of crystalline Thr and Met supplementation. The reduced-CP diets were formulated to an apparent digestible isoleucine:Lys ratio of 0.60, which equates to approximately a 3.1 percentage unit reduction in CP, and they were supplemented with Lys, Trp, Thr, and Met. Digestible Lys (**dLys**) levels of 0.96, 0.75, 0.60, and 0.48% were fed for the actual weight ranges of 25.3 to 41.0, 41.0 to 58.8, 58.8 to 82.3, and 82.3 to 109.7 kg, respectively. Diets (Tables 2 to 5) were formulated on a basis of apparent digestible AA, using total AA composition of the corn and soybean meal (Kidd et al., 1996) and AA digestibility values of Southern (1991). All diets were balanced relative to dLys according to Baker (1997) to Trp:Lys, Thr:Lys, total sulfur AA:Lys, Ile:Lys, and Val:Lys ratios of 0.18, 0.67, 0.62, 0.60, and 0.68 for pigs up to 58.8 kg, and 0.19, 0.70, 0.64, 0.60, and 0.68 ratios for pigs from 58.8 to 109.7 kg. Diets were formulated on a NE basis (Noblet et al., 1994) based on analyses of feed ingredients for ether extract, ash, NDF, and ADF (AOAC, 1984), as well as starch (Thivend et al., 1972). Net energy values used for corn, soybean meal, wheat middlings, and tallow were 2,731, 2,085, 1,665, and 7,255 kcal/kg, respectively. Dietary energy levels were reduced by approximately 17 kcal NE/kg with each 1 percentage unit reduction in CP according to NE calculations of Noblet et al. (1994). Amino acid concentrations of mixed diets were determined as in Exp. 1, with Met and Cys analyzed following performic acid oxidation (AOAC, 1984).

The equations of Brannaman et al. (1984) were used to obtain initial carcass composition to describe the rate of lean accretion of the experimental pigs for the carcass portion of the experiment. At the termination of Exp. 2, all gilts were slaughtered at a commercial facility. The left sides of three carcasses per pen were transported to the Louisiana State University Agricultural Center Meat Laboratory for the collection of carcass data. Cold carcass side weight (**CCW**), untrimmed ham weight, longissimus muscle area (**LMA**, by tracing the longissimus muscle surface at the 10th rib), and 10th-rib fat thickness (**TRF**) were obtained. Percentage of muscle was calculated according to the NPPC (1991) equation for ribbed carcasses containing 5% fat when carcass weight is not held constant.

Fat-free lean (**FFLEAN**) and total fat (**TOFAT**) were obtained by total body electrical conductivity (**TOBEC**) methods (Calkins et al., 1993; Higbie et al., 2002). The equations used to calculate FFLEAN and TOFAT contain the response variables that best predict either FFLEAN or TOFAT (Higbie, 1997) based on TOBEC scans of the cold (following a 24-h chill at 2°C) carcass sides. The FFLEAN was calculated as [7.005 + (8.938 × psoas muscle weight, kg) + (0.151 × TOBEC scan peak) − (0.520 × carcass temperature, °C)] (R^2 = 0.93) and TOFAT was calculated as [−9.528 + (1.181 × TRF, cm) + (0.660 × cold carcass side weight, kg) − (0.132 × TOBEC scan peak) + (0.465 × carcass temperature, °C)] (R^2 = 0.90). Percentage FFLEAN (**PFFLEAN**) was calculated as {[FFLEAN, kg/(CCW, kg × 2)] × 100} and percentage TOFAT (**PTOFAT**) was calculated as {[TOFAT, kg/(CCW, kg × 2)] × 100}. Fat-free lean in the ham (**HLEAN**) and total fat in the ham (**HTOFAT**) were obtained by TOBEC. Cold ham TOBEC scans were used to obtain HLEAN and HTOFAT. The HLEAN was calculated as [2.700 + (0.112

Table 2. Composition (%, as-fed basis) of early grower diets (25.3 to 41.0 kg) for Experiment 2[a]

	High CP			Low CP + AA		
Ingredients, % NE level, kcal/kg:	2,356	2,474	2,412	2,536	2,474	2,412
Corn	62.09	63.62	60.55	72.79	69.40	63.76
Soybean meal	33.60	33.50	33.05	23.75	23.40	22.90
Wheat middlings	—	—	4.05	—	4.25	10.45
Tallow	1.90	0.50	—	0.45	—	—
Defluorinated P	0.90	0.88	0.75	1.08	0.93	0.73
Limestone	0.70	0.70	0.80	0.60	0.70	0.85
NaCl	0.47	0.47	0.47	0.47	0.47	0.47
Vitamins[b]	0.05	0.05	0.05	0.05	0.05	0.05
Trace minerals[c]	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride-60	0.06	0.06	0.06	0.06	0.06	0.06
Copper sulfate[d]	0.07	0.07	0.07	0.07	0.07	0.07
L-Lysine·HCl	—	—	—	0.294	0.291	0.286
L-Tryptophan	—	—	—	0.020	0.019	0.017
L-Threonine	0.041	0.040	0.041	0.165	0.165	0.166
DL-Methionine	0.024	0.020	0.017	0.106	0.102	0.096
Calculated and analyzed total amino acid content, %						
Crude protein	21.13	21.20	21.37	17.34	17.56	17.85
Analyzed	20.24	20.96	20.88	16.16	17.72	17.88
Lys	1.17	1.17	1.18	1.13	1.14	1.15
Analyzed	1.11	1.15	1.15	0.99	1.11	1.09
Trp	0.26	0.26	0.26	0.22	0.22	0.22
Analyzed	0.24	0.25	0.28	0.22	0.22	0.22
Thr	0.83	0.83	0.84	0.81	0.81	0.82
Analyzed	0.77	0.79	0.81	0.69	0.78	0.78
TSAA[e]	0.74	0.74	0.74	0.71	0.72	0.73
Analyzed	0.70	0.75	0.73	0.60	0.63	0.64
Ile	0.89	0.90	0.90	0.71	0.71	0.72
Analyzed	0.86	0.89	0.88	0.64	0.74	0.72
Val	1.01	1.01	1.02	0.82	0.83	0.85
Analyzed	0.98	0.99	0.97	0.74	0.84	0.83
Calculated apparent digestible (d) amino acid content, %						
dLys	0.96	0.96	0.96	0.96	0.96	0.96
dTrp	0.20	0.20	0.20	0.17	0.17	0.17
dThr	0.64	0.64	0.64	0.64	0.64	0.64
dTSAA	0.60	0.60	0.60	0.60	0.60	0.60
dIle	0.73	0.73	0.73	0.58	0.58	0.58
dVal	0.82	0.82	0.82	0.66	0.66	0.66

[a]Diets formulated to contain 0.65% Ca and 0.55% P. Net energy values based on Noblet et al. (1994).
[b]Vitamin premix provided the following per kilogram of diet: vitamin A, 3,583 IU; vitamin D_3, 1,075 IU; vitamin E, 17 IU; vitamin B_{12}, 18 mg; riboflavin, 3.0 mg; niacin, 18 mg; pantothenic acid, 10.8 mg; and menadione, 2.3 mg. The sources are proprietary.
[c]Mineral premix provided the following per kilogram of diet: manganese, 178 mg; zinc, 318 mg; iron, 276 mg; copper, 5.6 mg; iodine, 1.1 mg; and selenium, 0.3 mg. The sources are proprietary.
[d]Provided 250 g Cu/ton.
[e]TSAA = total sulfur AA.

× TOBEC scan peak)] (R^2 = 0.93) and HTOFAT was calculated as [–2.189 – (0.102 × TOBEC scan peak) + (0.765 × ham weight, kg)] (R^2 = 0.74) (Higbie, 1997). Percentage HLEAN (PHLEAN) was calculated as [(HLEAN, kg/ham weight, kg) × 100] and percentage HTOFAT (PHTOFAT) was calculated as [(HTOFAT, kg/ham weight, kg) × 100]. Data for each response variable were analyzed by ANOVA using the GLM procedure of SAS (SAS Inst. Inc., Carey, NC), with replicate and dietary treatment included in the model. The pen of pigs was the experimental unit for all data. The PDIFF option of SAS was used to determine differences between treatment means.

Results

Experiment 1. Pigs maintained in the 33°C environment consumed less feed and consequently grew at a slower rate than pigs maintained in the 23°C environment, Table 6 (P < 0.01). Pigs fed the 12% CP diet without AA supplementation grew slower than pigs fed either the 16% CP diet or the 12% CP, AA-supplemented diet (P < 0.01). There was an environmental temperature × diet interaction for gain:feed (P < 0.01). Pigs fed the 12% CP, AA-supplemented diet had a lower gain:feed compared with pigs fed the 16% CP diet when fed in the 33°C environment but similar

Table 3. Composition (%, as-fed basis) of late grower diets (41.0 to 58.8 kg) for Experiment 2[a]

	High CP			Low CP + AA		
Ingredients, % NE level, kcal/kg:	2,585	2,526	2,467	2,585	2,526	2,467
Corn	71.11	72.54	69.44	80.75	77.73	72.37
Soybean meal	24.70	24.60	24.15	15.85	15.50	15.05
Wheat middlings	—	—	4.00	—	3.85	9.75
Tallow	1.75	0.45	—	0.45	—	—
Defluorinated P	1.08	1.05	0.93	1.23	1.10	0.90
Limestone	0.60	0.60	0.73	0.53	0.63	0.75
NaCl	0.47	0.47	0.47	0.47	0.47	0.47
Vitamins[b]	0.05	0.05	0.05	0.05	0.05	0.05
Trace minerals[c]	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride-60	0.06	0.06	0.06	0.06	0.06	0.06
Copper sulfate[d]	0.07	0.07	0.07	0.07	0.07	0.07
L-Lysine·HCl	—	—	—	0.264	0.262	0.257
L-Tryptophan	—	—	—	0.021	0.020	0.018
L-Threonine	0.011	0.010	0.011	0.123	0.123	0.124
DL-Methionine	—	—	—	0.043	0.038	0.033
Calculated and analyzed total amino acid content, %						
Crude protein	17.48	17.54	17.70	14.05	14.25	14.53
Analyzed	16.81	16.23	17.58	14.01	14.12	14.41
Lys	0.93	0.93	0.93	0.89	0.90	0.91
Analyzed	0.89	0.87	0.92	0.86	0.89	0.89
Trp	0.20	0.20	0.20	0.17	0.17	0.18
Analyzed	0.19	0.17	0.20	0.18	0.18	0.20
Thr	0.66	0.66	0.67	0.64	0.64	0.65
Analyzed	0.62	0.62	0.64	0.62	0.61	0.63
TSAA[e]	0.62	0.62	0.63	0.57	0.57	0.58
Analyzed	0.57	0.61	0.57	0.50	0.51	0.52
Ile	0.72	0.73	0.73	0.56	0.56	0.57
Analyzed	0.68	0.65	0.75	0.54	0.54	0.56
Val	0.84	0.84	0.85	0.67	0.68	0.69
Analyzed	0.82	0.78	0.88	0.69	0.69	0.71
Calculated apparent digestible (d) amino acid content, %						
dLys	0.75	0.75	0.75	0.75	0.75	0.75
dTrp	0.16	0.16	0.16	0.14	0.14	0.14
dThr	0.50	0.50	0.50	0.50	0.50	0.50
dTSAA	0.50	0.50	0.50	0.47	0.47	0.47
dIle	0.59	0.59	0.59	0.45	0.45	0.45
dVal	0.67	0.68	0.68	0.53	0.53	0.54

[a]Diets formulated to contain 0.65% Ca and 0.55% P. Net energy values based on Noblet et al. (1994).
[b]Vitamin premix provided the following per kilogram of diet: vitamin A, 3,583 IU; vitamin D_3, 1,075 IU; vitamin E, 17 IU; vitamin B_{12}, 18 mg; riboflavin, 3.0 mg; niacin, 18 mg; pantothenic acid, 10.8 mg; and menadione, 2.3 mg. The sources are proprietary.
[c]Mineral premix provided the following per kilogram of diet: manganese, 178 mg; zinc, 318 mg; iron, 276 mg; copper, 5.6 mg; iodine, 1.1 mg; and selenium, 0.3 mg. The sources are proprietary.
[d]Provided 250 g Cu/ton.
[e]TSAA = total sulfur AA.

gain:feed when fed in the 23°C environment. Pigs fed in the 33°C environment had lower concentrations of SUN than pigs fed in the 23°C environment ($P < 0.01$). Pigs fed the 16% CP diet had the highest level of SUN, pigs fed the 12% CP diet without AA supplementation had intermediate SUN concentrations, and pigs fed the AA-supplemented, 12% CP diet had the lowest SUN concentrations ($P < 0.01$).

Experiment 2. As shown in Table 7, from 25.3 to 41.0 kg BW (**GR1**), pigs had decreased rates of gain and gain:feed as dietary NE levels were reduced ($P < 0.05$). There were no effects of dietary CP on pig performance ($P > 0.10$) in GR1 pigs. From 41.0 to 58.8 kg (**GR2**), there were no effects of NE on pig performance ($P > 0.10$), but pigs fed the reduced CP, AA-supplemented diets consumed more feed ($P < 0.05$) and had a decreased gain:feed ($P < 0.10$) compared with pigs fed the high-CP diets. From 58.8 to 82.3 kg (**FN1**), lowering dietary NE reduced gain:feed ($P < 0.10$), but it had no effect on ADG ($P > 0.10$). Dietary CP had no effect on ADG or gain:feed ($P > 0.10$) in the FN1 period. A dietary CP × NE interaction was observed in ADFI ($P < 0.05$). Pigs fed the high-NE diet had the lowest feed intake when fed the high-CP diet but the highest feed intake when fed the reduced-CP, AA-supplemented diet. There was no impact of CP or NE on pig perfor-

Table 4. Composition (%, as-fed basis) of early finisher diets (58.8 to 82.3 kg) for Experiment 2[a]

	High CP			Low CP + AA		
Ingredients, % NE level, kcal/kg:	2,429	2,391	2,353	2,429	2,391	2,353
Corn	68.10	64.63	61.20	71.65	67.23	63.76
Soybean meal	16.90	16.45	16.10	8.80	8.45	8.15
Wheat middlings	13.00	16.95	20.75	17.15	21.95	25.75
Defluorinated P	0.20	0.075	—	0.23	0.08	—
Limestone	1.08	1.18	1.23	1.10	1.23	1.28
NaCl	0.47	0.47	0.47	0.47	0.47	0.47
Vitamins[b]	0.03	0.03	0.03	0.03	0.03	0.03
Trace minerals[c]	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride-60	0.06	0.06	0.06	0.06	0.06	0.06
Copper sulfate[d]	0.05	0.05	0.05	0.05	0.05	0.05
L-Lysine·HCl	—	—	—	0.230	0.226	0.223
L-Tryptophan	—	—	—	0.023	0.022	0.020
L-Threonine	0.012	0.014	0.016	0.113	0.113	0.114
Calculated and analyzed total amino acid content, %						
Crude protein	15.49	15.62	15.78	12.57	12.81	12.99
Analyzed	15.35	15.36	16.43	12.78	13.99	13.80
Lys	0.77	0.78	0.78	0.74	0.75	0.76
Analyzed	0.77	0.76	0.84	0.77	0.86	0.78
Trp	0.17	0.18	0.18	0.15	0.15	0.16
Analyzed	0.20	0.20	0.23	0.20	0.19	0.17
Thr	0.58	0.58	0.59	0.56	0.57	0.57
Analyzed	0.56	0.56	0.60	0.56	0.58	0.54
TSAA[e]	0.58	0.58	0.59	0.50	0.51	0.51
Analyzed	0.56	0.60	0.59	0.51	0.52	0.50
Ile	0.61	0.62	0.62	0.47	0.47	0.48
Analyzed	0.62	0.59	0.66	0.46	0.55	0.50
Val	0.74	0.75	0.76	0.60	0.61	0.62
Analyzed	0.79	0.76	0.83	0.63	0.71	0.68
Calculated apparent digestible (d) amino acid content, %						
dLys	0.60	0.60	0.60	0.60	0.60	0.60
dTrp	0.13	0.13	0.13	0.11	0.11	0.11
dThr	0.42	0.42	0.42	0.42	0.42	0.42
dTSAA	0.46	0.46	0.46	0.39	0.39	0.39
dIle	0.48	0.48	0.48	0.36	0.36	0.36
dVal	0.58	0.58	0.58	0.45	0.45	0.46

[a]Diets formulated to contain 0.55% Ca and 0.45% P. Net energy values based on Noblet et al. (1994).
[b]Vitamin premix provided the following per kilogram of diet: vitamin A, 2,150 IU; vitamin D_3, 645 IU; vitamin E, 10 IU; vitamin B_{12}, 11 mg; riboflavin, 1.8 mg; niacin, 11 mg; pantothenic acid, 6.5 mg; and menadione, 1.4 mg. The sources are proprietary.
[c]Mineral premix provided the following per kilogram of diet: manganese, 178 mg; zinc, 318 mg; iron, 276 mg; copper, 5.6 mg; iodine, 1.1 mg; and selenium, 0.3 mg. The sources are proprietary.
[d]Provided 180 g Cu/ton.
[e]TSAA = total sulfur AA.

mance from 82.3 to 109.7 kg (**FN2**). Overall, from 25.3 to 109.7 kg BW, neither CP nor NE level affected ADG or ADFI ($P > 0.10$). A CP × NE interaction in gain:feed was observed ($P < 0.10$) as pigs fed the high NE sequence of diets exhibited the best gain:feed when fed the high-CP sequence with the medium- and low-NE sequences being equal. However, pigs fed the high-NE sequence had similar gain:feed as pigs fed the medium-NE when fed the reduced-CP, AA-supplemented diets ($P > 0.10$).

Dietary CP and NE failed to interact on any carcass variable measured, and there were no main effects of dietary NE on carcass composition ($P > 0.10$, Table 8). Pigs fed the high-CP diets had a larger longissimus muscle area compared with pigs fed the reduced-CP, AA-supplemented diets ($P < 0.10$). There were no other effects of dietary CP on carcass composition ($P > 0.10$).

Discussion

Discrepancies between calculated and analyzed concentrations of CP were larger than expected, especially in the late finisher diets. Although extreme care was taken in feed preparation, sampling, and laboratory analysis, the large volumes of feed required in studies the size of Exp. 2 (approximately 4,480, 5,450, 7,490, and 10,940 kg per dietary treatment for GR1, GR2, FN1, and FN2, respectively), makes it unfeasible to set aside individual ingredients and analyze prior to mixing. There were also minor discrepancies between

Table 5. Composition (%, as-fed basis) of late finisher diets (82.3 to 109.7 kg) for Experiment 2[a]

	High CP			Low CP + AA		
Ingredients, % NE level, kcal/kg:	2,466	2,421	2,376	2,466	2,421	2,376
Corn	73.67	69.59	65.47	76.10	71.98	67.83
Soybean meal	11.85	11.40	10.90	4.30	3.95	3.60
Wheat middlings	12.45	17.00	21.65	17.20	21.70	26.25
Defluorinated P	0.33	0.18	0.03	0.33	0.18	0.03
Limestone	1.00	1.125	1.125	1.05	1.175	1.275
NaCl	0.47	0.47	0.47	0.47	0.47	0.47
Vitamins[b]	0.03	0.03	0.03	0.03	0.03	0.03
Trace minerals[c]	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride-60	0.06	0.06	0.06	0.06	0.06	0.06
Copper sulfate[d]	0.05	0.05	0.05	0.05	0.05	0.05
L-Lysine·HCl	—	—	—	0.213	0.210	0.206
L-Tryptophan	—	—	—	0.022	0.021	0.020
L-Threonine	—	—	—	0.085	0.085	0.086
Calculated and analyzed total amino acid content, %						
Crude protein	13.37	13.55	13.71	10.72	10.93	11.15
Analyzed	15.69	16.06	16.29	11.44	11.63	11.44
Lys	0.63	0.64	0.64	0.61	0.61	0.62
Analyzed	0.81	0.85	0.84	0.63	0.68	0.64
Trp	0.14	0.15	0.15	0.12	0.13	0.13
Analyzed	0.20	0.24	0.23	0.16	0.17	0.18
Thr	0.49	0.49	0.49	0.46	0.47	0.47
Analyzed	0.57	0.60	0.58	0.47	0.48	0.47
TSAA[e]	0.52	0.53	0.53	0.45	0.46	0.47
Analyzed	0.60	0.62	0.61	0.45	0.45	0.43
Ile	0.52	0.52	0.52	0.38	0.39	0.39
Analyzed	0.65	0.67	0.64	0.41	0.38	0.40
Val	0.64	0.65	0.66	0.51	0.52	0.54
Analyzed	0.80	0.83	0.82	0.57	0.55	0.57
Calculated apparent digestible (d) amino acid content, %						
dLys	0.48	0.48	0.48	0.48	0.48	0.48
dTrp	0.10	0.10	0.11	0.09	0.09	0.09
dThr	0.34	0.34	0.34	0.34	0.34	0.34
dTSAA	0.41	0.42	0.42	0.35	0.35	0.35
dIle	0.40	0.40	0.40	0.29	0.29	0.29
dVal	0.49	0.49	0.49	0.39	0.38	0.38

[a]Diets formulated to contain 0.55% Ca and 0.45% P. Net energy values based on Noblet et al. (1994).

[b]Vitamin premix provided the following per kilogram of diet: vitamin A, 2,150 IU; vitamin D_3, 645 IU; vitamin E, 10 IU; vitamin B_{12}, 11 mg; riboflavin, 1.8 mg; niacin, 11 mg; pantothenic acid, 6.5 mg; and menadione, 1.4 mg. The sources are proprietary.

[c]Mineral premix provided the following per kilogram of diet: manganese, 178 mg; zinc, 318 mg; iron, 276 mg; copper, 5.6 mg; iodine, 1.1 mg; and selenium, 0.3 mg. The sources are proprietary.

[d]Provided 180 g Cu/ton.

[e]TSAA = total sulfur AA.

calculated and analyzed concentrations of Lys, Trp, and Thr. Although exact reasons are unknown, AA analysis is inherently variable (Fontaine and Eudaimon, 2000), especially for Trp (Sato et al., 1984). In Exp. 1, dietary Lys levels were formulated to be similar to previously conducted experiments (Kerr and Easter, 1995; Kerr et al., 1995; Kerr et al., 2003) and were designed to help explain differences in pig performance, carcass composition, and heat production reported in those experiments. Digestible Lys levels formulated in Exp. 2 met levels previously deemed adequate for these pigs and diets were balanced relative to dLys according to Baker (1997) to eliminate any potential AA deficiencies.

The differences in feed intake due to environmental temperature in Exp. 1 are supported by others (Stahly et al., 1979; Nienaber et al., 1985; Le Bellego et al., 2002) who reported feed intake differences of approximately 15% in pigs fed at environmental temperatures similar to those we used. In contrast, Collin et al. (2001) reported a decrease in feed intake by 30% using 23 vs. 33°C. However, their experimental period lasted only 13 d compared to the 28 d in our trial, which may have exacerbated the impact of heat on voluntary feed intake. Improved growth performance has been achieved by feeding reduced-CP, AA-supplemented diets in heat stress conditions (Waldroup et al., 1976; Stahly et al., 1979; Chewning et al., 1995), which have

Table 6. Effect of ambient temperature and dietary CP level on performance and serum urea N of pigs, Experiment 1[a]

Treatment					
Temperature	Diet	ADG, g	ADFI, g	Gain:feed, g:kg	Serum urea N, mg/dL
23°C	16% CP	760	1,996	383[c]	23.1
	12% CP + AA	773	2,000	390[bc]	14.2
	12% CP	678	1,996	341[d]	19.0
33°C	16% CP	654	1,638	404[b]	19.0
	12% CP + AA	621	1,678	373[c]	12.0
	12% CP	556	1,714	327[d]	16.2
	Standard Error	13.9	38.2	6.3	0.62
Main effect					
23°C		737	1,997	371	18.8
33°C		610	1,677	368	15.7
16% CP		707[b]	1,817	394	21.1[b]
12% CP + AA		697[b]	1,839	382	13.1[d]
12% CP		617[c]	1,855	334	17.6[c]
Source of variation, *P*-value					
Temperature		0.01	0.01	0.53	0.01
Diet		0.01	0.61	0.01	0.01
Temperature × diet		0.25	0.61	0.01	0.29

[a]There were 10 replications per treatment with four pigs per pen. Average initial weight was 28.7 kg, average final weight was 47.5 kg. Pigs were on treatment for 28 d. AA represents Lys, Trp, and Thr supplementation.
[b,c,d]Within a column, means with a different superscript letter differ ($P < 0.05$).

been related to decreased HP (Noblet et al., 1987; Le Bellego et al., 2001; Kerr et al., 2003). Thus, the reduction in feed intake due to high ambient temperature should have been less in pigs fed the reduced-CP, AA-supplemented diets. However, this was not the case. The lack of an interaction between temperature and diet on feed intake suggests little effect of low-CP, AA-supplemented diets on feed intake modification at high ambient temperatures, and consequently on ADG. Had we utilized finishing pigs, a diet × temperature interaction may have been expected because higher temperatures have a larger negative impact on feed intake at heavier BW (Quiniou et al., 2000). However, our data are supported by those of Lopez et al. (1994) and Le Bellego et al. (2002), who also reported no interaction between environmental temperature and dietary treatment on feed intake or growth rates in finishing or growing-finishing pigs, respectively.

The lack of a dietary CP effect on ADFI in Exp. 1 and in all but GR2 (41.0 to 58.8 kg) of Exp. 2 agrees with others using similar reductions in CP (Kerr et al., 1995; Knowles et al., 1998). Although numerically greater feed intakes in pigs fed-low CP, AA-supplemented diets were reported by Kerr et al. (1995), Cromwell et al. (1996), and Knowles et al. (1998), no numerical feed intake differences were noted in trials by Schoenherr (1992), Tuitoek et al. (1997a), and Smith et al. (1999). In contrast, Le Bellego et al. (2002) reported that pigs fed reduced-CP, AA-supplemented diets had lower feed intakes than pigs fed high-CP diets. Thus, in trials covering extended periods of growth, dietary CP seems to have little impact on feed intake, provided that amino acids are adequately fortified.

Dietary NE had no effect on overall ADFI in Exp. 2. Although it is well known that changes in dietary energy can have large impacts on feed intake (NRC, 1987), most of these studies have dealt with relatively large differences in dietary energy levels. In Exp. 2, the difference in dietary NE from the high NE to low NE was only 124, 118, 76, and 90 kcal NE/kg in GR1, GR2, FN1, and FN2, respectively. These differences in NE may have been too small to influence feed intake, or the variation observed in feed intake in Exp. 2 overshadowed any potential NE effect. Smith et al. (1999) reported a difference in feed intake due to dietary NE difference of 65 kcal/kg, although feed intake only differed by approximately 35 g/d. The effect of NE on pig growth from 25.3 to 41.0 kg BW suggests that pigs at this age may have been more sensitive to dietary NE and may have been in an energy-dependent phase of growth (Campbell et al., 1985). Later stages of growth were unaffected by dietary NE, which suggests that their growth curves may have leveled out so that energy was no longer limiting protein accretion. In general, changing dietary NE through adjustments of corn, SBM, wheat middlings, and tallow within this narrow energy range has no effect on growth or feed intake.

As expected, pigs in Exp. 1 fed the 12% CP diet without AA supplementation grew at a slower rate than pigs fed either the 16% CP diet or pigs fed the 12% CP diet with Lys, Trp, and Thr supplementation,

Table 7. Effect of CP and NE level on growing-finishing pig performance, Experiment 2[a]

Treatment		GR1 (25.3 to 41.0 kg)			GR2 (41.0 to 58.8 kg)			FN1 (58.8 to 82.3 kg)			FN2 (82.3 to 109.7 kg)			Overall (25.3 to 109.7 kg)		
CP	NE	ADG	ADFI	G:F	ADG	ADFI	G:F	ADG	ADFI	G:F	ADG	ADFI	G:F	ADG	ADFI	G:F
High	High	748	1,686	0.444	835	2,167	0.386	867	2,218[c]	0.392	781	2,511	0.310	807	2,188	0.369[x]
High	Med	715	1,748	0.410	859	2,194	0.391	814	2,270[bc]	0.360	731	2,559	0.286	774	2,246	0.345[yz]
High	Low	685	1,737	0.395	862	2,120	0.392	823	2,316[b]	0.355	784	2,550	0.308	789	2,259	0.349[y]
Low	High	745	1,805	0.412	851	2,272	0.375	858	2,331[b]	0.368	713	2,499	0.285	784	2,270	0.345[yz]
Low	Med	720	1,723	0.420	840	2,279	0.369	844	2,290[bc]	0.369	714	2,487	0.286	774	2,240	0.346[yz]
Low	Low	680	1,767	0.387	837	2,191	0.382	823	2,280[bc]	0.361	729	2,556	0.285	765	2,278	0.336[z]
SEM		25.0	39.1	0.014	22.8	34.3	0.010	22.5	28.9	0.0099	36.3	41.4	0.013	13.6	27.5	0.005
Main effects																
High CP		716	1,724	0.416	852	2,187	0.390	835	2,268	0.369	766	2,540	0.301	790	2,231	0.354
Low CP		715	1,765	0.406	843	2,248	0.375	842	2,301	0.366	719	2,514	0.285	774	2,263	0.342
High NE		746[b]	1,746	0.428[b]	843	2,219	0.381	863	2,275	0.380[x]	747	2,505	0.297	796	2,229	0.357
Med NE		718[bc]	1,736	0.415[bc]	850	2,237	0.380	829	2,280	0.364[xy]	723	2,523	0.286	774	2,243	0.345
Low NE		682[c]	1,752	0.391[c]	849	2,196	0.387	823	2,298	0.358[y]	756	2,553	0.296	777	2,268	0.343
Source of variation, *P*-value																
CP		0.96	0.20	0.38	0.62	0.04	0.08	0.71	0.18	0.73	0.12	0.45	0.12	0.15	0.17	0.01
NE		0.05	0.92	0.03	0.94	0.49	0.76	0.18	0.70	0.08	0.63	0.52	0.61	0.24	0.36	0.01
CP × NE		0.98	0.18	0.31	0.64	0.22	0.80	0.67	0.04	0.20	0.77	0.62	0.52	0.62	0.27	0.06

[a]Values represent the mean of nine replications per treatment with 13 gilts per pen with ADG and ADFI reported in g/d. GR1 = early grower, GR2 = late grower, FN1 = early finisher, FN2 = late finisher.

[b,c]Within a column, means with a different superscript letter differ ($P < 0.05$).

[x,y,z]Within a column, means with a different superscript letter differ ($P < 0.10$).

Table 8. Effect of CP and NE level on carcass composition, Experiment 2[a]

Treatment		Carcass weight, kg	Ham weight, kg	Ham butt fat, cm	Longissimus area, cm^2	Tenth rib fat, cm	NPPC muscle, %	Carcass TOBEC						Ham TOBEC[b]	
								Fat-free lean		Fat		Lean gain, g/d	Lean:fat ratio	Fat-free lean, kg	Fat, kg
CP	NE							kg	%	kg	%				
High	High	41.62	9.77	1.68	45.76	2.71	52.47	40.35	48.55	26.58	31.87	285	1.55	38.56	27.02
High	Med	41.23	9.81	1.68	46.40	2.54	53.58	39.98	48.70	25.96	31.21	284	1.62	38.65	26.34
High	Low	41.67	9.70	1.71	45.13	2.63	52.65	39.64	47.71	27.00	32.23	278	1.53	37.89	27.71
Low	High	41.57	9.75	1.70	43.51	2.82	51.67	38.95	47.08	27.85	33.16	269	1.47	37.70	27.83
Low	Med	41.57	9.87	1.59	46.15	2.56	53.26	40.68	49.03	25.93	31.05	291	1.61	39.30	26.08
Low	Low	40.05	9.38	1.54	42.20	2.39	52.98	38.23	47.92	25.39	31.48	266	1.57	36.48	25.98
SEM		0.855	0.182	0.095	1.237	0.152	0.933	0.756	0.750	1.131	0.911	7.1	0.072	0.823	1.003
Main effects															
High CP		41.50	9.76	1.69	45.77[y]	2.62	52.90	39.99	48.32	26.51	31.77	282	1.57	38.37	27.02
Low CP		41.06	9.67	1.63	43.95[z]	2.59	52.63	37.29	48.01	26.39	31.90	275	1.55	37.82	26.63
High NE		41.59	9.76	1.72	44.64	2.77	52.07	39.65	47.81	27.22	32.51	277	1.51	38.13	27.42
Med NE		41.40	9.84	1.63	46.28	2.55	53.42	40.33	48.87	25.94	31.13	287	1.61	38.98	26.21
Low NE		40.86	9.54	1.62	43.66	2.51	52.81	38.94	47.82	26.19	31.85	272	1.55	37.18	26.84
Source of variation, *P*-value															
CP		0.53	0.54	0.47	0.08	0.80	0.73	0.26	0.62	0.90	0.86	0.25	0.75	0.42	0.64
NE		0.68	0.25	0.53	0.12	0.21	0.36	0.20	0.28	0.50	0.33	0.12	0.35	0.11	0.49
CP × NE		0.49	0.55	0.37	0.54	0.50	0.83	0.29	0.41	0.45	0.52	0.24	0.72	0.44	0.45

[a]Values represent the mean of nine reps per treatment with three pigs per pen.
[b]Represents the estimation of carcass lean and fat using ham TOBEC equations.
[y,z]Within a column, means with a different superscript letter differ ($P < 0.10$).

regardless of environmental temperature. In both experiments, pigs fed the reduced-CP, AA-supplemented diets grew similarly to pigs fed the high-CP diets. Only during the FN2 phase of Exp. 2 did pigs fed the reduced-CP, AA-supplemented diet have any indication of slower growth than pigs fed the high-CP diet. Similar growth between pigs fed high- or reduced-CP, AA-supplemented diets has been shown previously (Kerr et al., 1995; Cromwell et al., 1996; Tuitoek et al., 1997a; Knowles et al., 1998). Smith et al. (1999), however, reported that pigs grew faster on higher CP diets.

In Exp. 1, there was an interaction between diet and temperature. Pigs fed the AA-supplemented, 12% CP diet in the 23°C environment had a feed conversion similar to pigs fed the 16% CP diet, but the pigs fed the AA-supplemented, low-CP diet had a reduced feed conversion in the 33°C environment. This response was not expected and contrary to the concept of the ability of dietary HI to affect pig performance. One might have expected that a diet containing less HI should result in equal or better feed conversion in a hot environment than a diet containing a greater amount of HI. The fact that pigs fed the unsupplemented 12% CP diet had a reduced feed conversion was fully anticipated (Kerr et al., 1995). In Exp. 2, there was an interaction between dietary CP and NE. Pigs fed the high-NE sequence of diets exhibited the best feed conversion when fed the highest CP sequence, whereas feed conversions in pigs fed the medium- and low-NE sequences were equal. In contrast, pigs fed the high-NE sequence had similar feed conversion as pigs fed the medium NE when fed the reduced-CP, AA-supplemented diets. Whether this is due to the level of wheat middlings supplemented in the medium- and low-NE diets, greater than 15%, and the lack of tallow supplementation in the two finisher diets, is unclear. Assuming we had fully accounted for both NE and AA levels in our diet formulation, the fact that pigs fed the low-CP, AA-supplemented diet had reduced feed conversion was somewhat surprising. However, other researchers also have shown that pigs fed low CP, AA-supplemented diets have reduced feed conversion than pigs fed higher levels of dietary CP (Tuitoek et al., 1997a; Knowles et al., 1998; Smith et al., 1999), whereas Lopez et al. (1994), Kerr et al. (1995), and Cromwell et al. (1996) reported equal feed conversions.

The decrease in SUN concentrations in pigs fed in the 33°C environment was expected due to a decrease in feed intake. In contrast, Lopez et al. (1994) reported an increase in SUN levels in finishing pigs maintained in a hot diurnal environment when measured on d 14, but not on d 29, even though feed intake was decreased by elevation of the environmental temperature. The decrease in SUN levels in pigs fed the 12% CP diet supplemented with Lys, Trp, and Thr indicates a reduction in the amount of excess AA being consumed and is similar to that observed by others (Lopez et al., 1994; Ward and Southern, 1995; Knowles et al., 1998).

The lack of any effect of NE on carcass composition was somewhat unexpected because diets were adjusted for NE differences due to dietary CP levels. Some difference in fat deposition might have been expected given the fact that pigs fed the high-NE diets consumed 3% more energy than pigs fed the low-NE diets. However, estimation of total energy intake over the 108-d trial approximated 18,500 kcal, which would have amounted to a difference in body fat of only 2 kg. Thus, differences in dietary NE utilized in Exp. 2 were apparently not large enough to influence carcass fatness. Smith et al. (1999) reported greater 10th-rib fat depths and lower lean percentages in ultrasound data due to increasing dietary NE, but their commercial slaughter data showed no differences in carcass characteristics due to dietary NE. Likewise, Knowles et al. (1998) reported few effects of dietary NE levels on carcass traits of pigs. However, in their data obtained from a commercial slaughter plant from the same experiment, pigs fed the intermediate level of NE had lower rates of fat gain per day, and pigs fed the lowest level of dietary NE had greater 10th-rib fat depth, but estimated lean percentage did not differ.

The impact of dietary CP on carcass composition reported in literature is variable. Schoenherr (1992), Kerr et al. (1995), Cromwell et al. (1996), and Smith et al. (1999) all reported that pigs fed the low-CP, AA-supplemented diets produced carcasses with slightly less percentage lean. In contrast, Noblet et al. (1987), Lopez et al. (1994), Tuitoek et al. (1997b), and Knowles et al. (1998) indicated little effect of dietary CP on carcass lean percentage. Excluding the Kerr et al. (1995) data, where diets may have been low in the total sulfur AA-to-Lys ratio, the reasons for these discrepancies are not clear. These different responses are especially perplexing given the fact that the current data along with Knowles et al. (1998) and Smith et al. (1999) have tried to balance the NE level of the diets for these differences in calculated NE. However, because HP is largely affected by the composition of body weight gain (Quiniou et al., 1995; van Milgen et al., 1998) and because pigs fed the high-CP diet and low-CP, AA-supplemented diets in Exp. 2 had similar gain and carcass composition, potential HI differences between diets will have little impact on overall animal performance or carcass composition.

Implications

The results of these experiments indicate that low-crude protein (3% reduction), amino acid-supplemented diets can be fed with no serious adverse effects on growth, gain:feed, or carcass traits. These data do not support the idea that feeding a low-crude protein, amino acid-supplemented, corn-soybean meal based diet or formulating these diets on a net energy basis will have a discernible effect on pig performance or carcass composition in pigs maintained in heat-stressed environments.

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